TESTIMONY/COMMENTS OF DENNY S. PARKER RELATED TO DRAFT WASTE DISCHARGE REQUIREMENTS FOR THE SACRAMENTO REGIONAL WASTEWATER TREATMENT PLANT TENTATIVE ORDER OF THE CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, CENTRAL VALLEY REGION, SEPTEMBER 3, 2010

On behalf of the

SACRAMENTO REGIONAL COUNTY SANITATION DISTRICT (SRCSD)

I am Dr. Denny S. Parker, NAE, P.E. (Certificate No. 24965). A copy of my resume which describes my education and representative work experience is attached. I have been registered in the State of California since 1975. I have received three degrees from the University of California at Berkeley (B.S. Civil Engineering, 1965, M.S. Civil Engineering, 1966, and Ph.D. in Engineering, 1970) and the specialization of my last two degrees was environmental engineering. I have 40 years of work experience with a national environmental engineering firm, Brown and Caldwell. I am an officer of the firm (Senior Vice President) and my current position is Director of Technology. Here, my broad experience in nutrient removal in wastewater treatment plants is especially applicable, as well as my consistent focus on wastewater process design and planning. I am widely recognized for my expertise in process engineering; as evidence of this, I have won seven prestigious awards, including election to the National Academy of Engineering (NAE) in 2004. The citation in the NAE election was: "For significant advances in the scientific understanding, engineering development, and process design of chemical, physical and biological processes for the treatment of wastewater."

I have specific experience of relevance to the technical achievability of the effluent ammonia and nitrate concentrations listed in the draft permit released on September 3, 2010, for the Sacramento Regional Wastewater Treatment Plant (SRWTP). I am currently Co-Principal Investigator for a research investigation for the Water Environment Research Foundation (WERF) in which the Water Environment Federation (WEF) is also a participant. This investigation is completing its third year, with preparation of a draft and then final report. The report is titled: *WEF/WERF Study Quantifying Nutrient Removal Technology Performance* (WEF/WERF Investigation). It will be submitted in draft for its second review in several weeks and it is anticipated that it will be published in final form by WERF by the end of 2010. The work is directly applicable and is one of the main sources upon which I base my conclusions.

The approach in the WEF/WERF Investigation was to identify the best performing nutrient removal plants across North America and to survey a large percentage -- as many as we practically could. Nitrification performance was also examined, because of concerns whether low "maximum day" ammonia concentrations could be achieved. Our survey covered 22 plants accomplishing either nitrification, or both nitrification and denitrification, or phosphorus removal. Two of the plants were picked that included only nitrification and not a second denitrification step, but of course all of the plants achieving exemplary nitrogen removal accomplished a high degree of nitrification as their first step in nitrogen removal. The focus was on technologies that had records available for at least 36 months of operation and were at full scale, experiencing all of the issues a real plant faces. Emerging technologies for which only pilot data were available were considered too

idealized and not included, since the pilot data would not properly reflect the statistical variability of full scale plants.

A major finding of the WEF/WERF Investigation was that statistical variability is a characteristic of all the exemplary plants and that this variability should be recognized in both evaluation of technologies (e.g., stratifying them in terms of their capabilities) in an engineering environment as well as determining the appropriate effluent limits in the regulatory permit setting environment. A second major finding is that local conditions impact the performance achieved on average and in terms of statistical variability. These factors include process design, climate impacts, wet weather flow influences, attributes of the service area, variation in influent flows and loadings, presence or absence of industrial contributions, whether solids processing is accomplished on the same site, sustained or interrupted supplies of chemicals, construction impacts, mechanical failures, the difficulty in operating the process, the ability to automate the controls of a process, the closeness of operation to design flows and loadings and others. This makes it inadvisable to directly translate either the average performance or the statistical variability directly from a known plant situation to another location where there is no supporting database (for example, for a plant converting from secondary treatment to nitrification or nitrogen removal).

Concern over statistical variability is a characteristic of advanced treatment processes that are targeted at very low concentrations and not one for secondary treatment processes with, for example, 30/30 (BOD/SS) monthly standards. In essence, in an advanced treatment plant targeting low effluent concentrations close to zero, there are no negative values during a month to offset high positive values. There is less concern over statistical variability with secondary treatment; in the 30/30 case, where, for example, a daily value of 45 mg/L is offset by another at 15 mg/L, the two events together do not contribute to a monthly violation. This brings home the point of the need to consider statistics in a regulatory permit setting environment for advanced treatment applications.

Below I:

1. Examine the feasibility of the concentration established in the draft permit for monthly average nitrate-nitrogen concentration of 0.26 mg/L.
2. Examine the feasibility of the concentration established in the draft permit for the maximum day ammonia-nitrogen concentration of 2.2 mg/L.

FEASIBILITY OF MONTHLY AVERAGE NITRATE REQUIREMENT

Purpose

The purpose of this assessment is to evaluate the technical achievability of the monthly average nitrate-nitrogen concentration of 0.26 mg/L, as stated in Table 6, Effluent Limitations, of the draft permit.

Approach

The draft permit's rationale for establishing the nitrate requirement was evaluated by first examining statements provided in the narrative. Once the basis was established, the capabilities of available technologies were compared to the nitrate requirement to determine if it is achievable with current technologies available to SRCSD.

Findings

- At various places in the draft permit, terms such as "full denitrification" (Fact Sheet F-44) or "Best Practical Treatment and Control" (BPTC, Fact Sheet F-56) are described as the desired level of treatment for nitrate removal. My analysis below is related to the performance of full denitrification facilities. I have made no evaluation of whether full denitrification is BPTC for the SRWTP.

- The specific origin of the monthly average requirement is stated in the draft permit as follows:

  > The removal of nitrate and nitrite (i.e., denitrification) is technologically feasible and is often used at POTWs. Therefore, due to the concerns of adverse effects to aquatic life from nitrogen this Order requires the wastewater is fully denitrified. An average monthly effluent limit of 0.26 mg/L for nitrate (as nitrogen) is included in this Order. This is based on the Discharger's study prepared by Larry Walker Associates, titled, "Technical Memorandum: Analysis of Costs and Benefits of Advanced Treatment Alternatives for the Sacramento Regional Wastewater Treatment Plant," dated May 2010. (Fact Sheet, F-71.)

- The cited Larry Walker Associates Technical Memo (LWATM) identifies "the projected mean effluent concentrations of constituents of interest: for five advanced treatment train alternatives" (page IV, Executive Summary) in Table ES-4 (page 5, Executive Summary). Two trains (B and C) are projected to mean effluent concentrations for nitrate-N of 0.26 mg/L. Examination of the appendix prepared by Carollo Engineers (CE) in the LWATM states that these are estimated effluent concentrations, as noted in the following statement:

  > The estimated removal efficiencies beyond secondary treatment were developed based on reported literature values from academic and professional journals and conference proceedings, published and unpublished pilot plant data, and standard textbook references. The estimated final effluent concentrations are presented in this TM for planning purposes only. Additional pilot scale studies will be required to determine removal efficiencies for the TPs and the final design criteria, should any of these advanced treatment processes actually be required and implemented for SRWTP.

  This indicates to the writer that the LWATM did not intend the performance level of the treatment trains examined to be a basis of permit setting and that in fact, further investigation about performance of nitrogen removal facilities would be required for both engineering and permit writing purposes.

- A further clarification of the meaning of the averaging period used in establishing mean concentrations in the LWATM was sought from the SRCSD and provided in the form of a September 30, 2010 Project Memorandum, titled "Comments on the nitrate and ammonia nitrogen effluent limit in the SRWTP Tentative Order R5-2010 (September 3, 2010)," by Steve McDonald, of Carollo Engineers. That memo indicates that 0.26 nitrate-N mean performance estimate represents an average of the effluent concentration over a three year period.

- The long term averaging period for the mean estimate of performance is also consistent with the way the performance data was used in the main body of the LWATM (page 4-25) to calculate the changes in nitrate concentrations that would occur with the various levels of nitrate removal provided by the five treatment trains. As discussed, the changes are compared to ambient median concentrations from a long term data base. Thus, they do not represent maximum month permit limit conditions.

- Given the caution already stated about directly translating either the average performance or the statistical variability from a known plant situation to another location for use in the regulatory permit setting environment, the statistical performance of exemplary plants surveyed can be used to benchmark the value set in the draft permit for nitrate. When examining the WEF/WERF Investigation database, none of the plants could meet the draft permit requirement. The draft permit is on a monthly average basis and when examining the maximum month performance of the exemplary plants in the database, not a single plant could meet the 0.26 mg/L requirement. This reflects the statistical variability of exemplary plants, where the ratio of maximum month effluent quality to three year average effluent quality ranged from 1.7 to 4.8.

Conclusions Concerning Denitrification

The plants in the WEF/WERF Investigation database are amongst the best performing plants in the nation with respect to nutrient removal. As such, they certainly would represent the concepts of "full denitrification," at least with respect to the capability of technology. Based upon the definition of full denitrification, as defined by the exemplary plants in the WEF/WERF Investigation database, I can identify no plant in the United States (US) that consistently meets the criterion of 0.26 mg/L nitrate-N on a monthly average basis. In my opinion, the proposed limit is not technologically attainable without supplemental treatment well beyond that normally provided for nutrient removal, nor does it describe what can be met with "full denitrification," at least with technologies typically applied in the US for nitrogen removal as judged by comparison to the exemplary plants in the WEF/WERF Investigation database.

FEASIBILITY OF DAILY MAXIMUM AMMONIA NITROGEN REQUIREMENT

Purpose

The purpose of this assessment is to evaluate the technical achievability of the maximum day ammonia-nitrogen concentration of 2.2 mg/L as stated in Table 6, Effluent Limitations, of the draft permit.

Approach

The draft permit's rationale for establishing the ammonia nitrogen requirement was evaluated by first examining statements provided in the narrative. Once the basis was established, the capabilities of available technologies were compared to the ammonia-nitrogen requirement to determine if it is achievable with current technologies available to the SRCSD.

Findings

- At various places in the draft permit, engineering terms such as "full nitrification" (Fact Sheet F-39) or "Best Practical Treatment and Control" (BPTC, Fact Sheet F-56) are described as the desired level of treatment for ammonia-nitrogen removal. My analysis below is related to the performance of full nitrification facilities. I have made no evaluation of whether full nitrification is BPTC for the SRWTP.

- Given the caution already stated about the use of directly translating either the average performance or the statistical variability directly from a known plant situation to another location for use in the regulatory permit setting environment, the statistical performance of exemplary plants surveyed can be used to benchmark the value set in the draft permit for maximum day ammonia value. When examining the WEF/WERF Investigation database, only a single plant could meet the proposed maximum day permit for ammonia-N concentration of 2.2 mg/L.

Conclusions Concerning Nitrification

The plants in the WEF/WERF Investigation database are amongst the best performing plants in the nation with respect to nitrification. As such, they certainly would represent the concepts of "full nitrification," at least with respect to the capability of technology. Based upon the definition of full nitrification, as defined by the exemplary plants in the WEF/WERF Investigation database, I could only identify one plant in the United States (US) that meets the maximum day ammonia-nitrogen concentration of 2.2 mg/L. The proposed limit does not define "full nitrification," at least with technologies typically applied in the US for nitrification. In my opinion, considering the statistical variability in the performance of nitrification processes, the proposed limit for maximum day ammonia-nitrogen would be extremely difficult to meet on a consistent basis. Measures beyond what would be considered "full nitrification" would have to be considered so as to deal with this issue. This would come at significant additional expense.

Experience Summary

Dr. Denny Parker has developed and implemented new wastewater processes and modifications and regularly serves as process design reviewer for major wastewater and reclaimed water projects. Dr. Parker has lectured at EPA technology transfer sessions across the U.S. on the subjects of nitrogen removal, innovative and alternative technologies, and oxidation pond upgrading. He has played significant roles in wastewater master planning and facilities planning projects for major communities and metropolitan areas. He is the inventor, co-inventor of four widely used treatment processes: the Trickling Filter/Solids Contact process, the flocculator-clarifier, the Classifying Selector, and the BAR process for bioaugmentation of nitrification in the activated sludge process. Dr. Parker has won seven national awards for his process engineering work, including election to the National Academy of Engineering in 2004.

Assignment

Education

Ph.D., Engineering, University of California, Berkeley, 1970

M.S., Environmental Engineering, University of California, Berkeley, 1966

B.S., Civil Engineering, University of California, Berkeley, 1965

Registration

Registered Professional Engineer (Civil) 24965, California, 1975

Registered Professional Engineer (Civil) 20319, Kentucky, 1998

Experience

40 years

Joined Firm

1970

Relevant Expertise

- *Facilities planning*
- *Process engineering and process development*
- *Innovative wastewater treatment technologies*
- *Secondary clarifier design and upgrading*
- *Lagoon upgrading*
- *Development of trickling filter/solids contact process*
- *Invention of the biological contact process for wet weather treatment*
- *Suspended growth and attached growth nitrification and denitrification systems*

Wastewater Planning and Design

WWTP Master Plan, Napa Sanitation District, Napa, California

Process Engineering Reviewer. Dr. Parker is reviewing the evaluation of treatment process capacity requirements and process alternative development for this master planning effort. This project involves developing a comprehensive master plan and capacity analysis for the District's WWTP. The existing plant includes both activated sludge and oxidation pond systems operating in parallel, with complete biosolids treatment. The plant currently produces recycled water and also discharges to the Napa River during the wet season. The team reviewed existing facilities and evaluated capital improvements needed for growth and adherence to more stringent regulations anticipated in the future. A comprehensive assessment of existing capacity was followed by alternatives development, with a business case evaluation used to compare alternatives. The duration of the $1.5 million project will be 18 months, with completion scheduled for late 2010.

DCWASA Design of Enhanced Nitrogen Removal Facilities at Blue Plains

Lead Process Technologist. Dr. Parker leads selection and application of core project technology solutions for an increase in nitrogen removal capability to reduce the current effluent TN from to 6 to 3 mg/L TN on annual average basis. This design project for the 350 mgd plant serving our national capital considered multiple technologies, finally selecting extending the current separate stage nitrification/denitrification activated sludge system with additional denitrification and post aeration tanks. He led the efforts to ensure that saturated conditions produced by denitrification conditions did not lead to flotation in the final sedimentation tanks. Dr. Parker also provided overall review of the process design for enhanced nitrification and denitrification including a new waste carbon storage facility as well as expansion in the methanol facility and conversion of an existing denitrification stage to a nitrification stage.

WWTP Master Plan, City of San Jose, California

Secondary Treatment/Advanced Treatment Process Lead. Dr. Parker led the evaluation of treatment process capacity requirements, and process alternative development for this current master planning effort. The Carollo/Brown and Caldwell Team is developing a Plant Master Plan that fully integrates technical, regulatory, and financial solutions with a "green," whole-systems approach that maximizes community benefits and provides a state-of-the-art wastewater treatment system. Effluent requirements considered include providing for current requirements (complete nitrification) plus

extensions nitrogen removal to TN levels of 8 and 3 mg/L annually. Liquid treatment alternatives evaluated include conventional activated sludge with anoxic selectors, step feed BNR, membrane bioreactors and effluent polishing with denitrification.

WERF/WEF Study Quantifying Nutrient Removal Technology Performance

Co-Principal Investigator (WERF)/Workshop Chair (WEF). This unique joint effort of the Water Research Foundation and the Water Environment Federation is surveying the best performing nutrient removal plants in the US (22 plants), using both the plant data, design data and operating schemes to identify the LOT (Limit of Technology) for conventionally nutrient removal technologies. LOT has previously loosely been described as meeting a TN of 3.0 mg/L or a TP of 0.1 mg/L without specifying any averaging period. Parker developed the experimental plan, worked with a steering committee that developed the statistical analysis approach and recruited the plant managers and volunteers participating in the investigation. Dr. Parker provided engineering assessment of the results in progress reports and technical papers. Results from the investigation will impact the wastewater industry broadly, in terms of establishing technology rankings, guidance for features or operating schemes that enhance reliability and the appropriate use of performance statistics in permit writing.

Anaerobic Selector Investigation, Santa Rosa, California

Technical Lead. At the Laguna Wastewater Treatment Facility in Santa Rosa, CA, Dr. Parker led the demonstration scale conversion of the anoxic selector to an anaerobic selector to invoke biological phosphorus removal. Principal concerns were: 1) maintaining selector effectiveness in SVI control in the anaerobic mode, 2) controlling floc strength to minimize filter influent turbidity, and 3) preventing premature release of phosphorus in the RAS. A secondary concern was the return of nitrate in the RAS and the extent to which denitrification might deplete the availability of readily degradable organics for inducing the biological phosphorus mechanism required to make the anaerobic selector work successfully. Operating conditions for the trial conditions were defined and a sampling program was developed. Desired SVI, DO, RAS nitrate and phosphorus levels were achieved. Plant staff and Brown and Caldwell analyzed the test data and jointly established conditions that met the several criteria necessary for a success biological phosphorus removal application: good P removal, SVI control and creation of strong floc. The successful trial allowed the plant to confirm that only minimal capital needs would be required if a conversion to nutrient removal is required in the future.

Water Pollution Control Plant Infrastructure Plan, City of Sunnyvale, California

Liquid Treatment Process Engineer. Dr. Parker developed two major alternatives for Sunnyvale's treatment future, one based on upgrading and refurbishing existing facilities, the other based on adoption of new state-of-the-art technologies to replace the existing facilities. Suggested sub-alternatives to consider are 1) repair and rehabilitation, plus debottlenecking the existing processes to enhance performance and flexibility; 2) transitioning to a new "high technology" state-of-the-art facility; 3) transitioning to a conventional state-of-the-art facility; or 4) a combination of some state-of-the-art technologies with upgrades of some of the City's existing facilities. Effluent requirements considered current conditions (ammonia levels seasonally to 5 mg/L) to full nitrification in the future. Alternatives considered include modification of current nitrifying trickling filters for higher efficiency, to conventional activated sludge and membrane bioreactors.

Facility Plan Update, Metro Wastewater Reclamation District (Denver Metropolitan Region), Colorado

Member Expert Peer Review Panel. This facility plant update concerns the phased upgrading of Metro's facilities over a 30 year period to daily maximum total nitrogen TN requirements of 10 mg/L with monthly averages as low as TN of 3 mg/L and total phosphorus (TP) average effluent of 0.03 to 0.1 mg/L The existing North (now BNR) and South complexes (now high purity oxygen activated sludge) must be reconfigured while staying within effluent requirements and expanding the regional plant from current flows of 160 mgd to predicted flows of 220 mgd (ADWF). Technologies included in the design include a nitrifier bioaugmentation process developed by Dr. Parker (at Appleton, WI) to accelerate nitrification rates and minimize future aeration tank requirements (the BAR process). Dr. Parker influenced the selection of design criteria, such as developing a way for anaerobic selector and classifying selectors to work in the plant in concert with the bioaugmentation scheme, thereby reducing the propensity of the activated sludge process to "bulk" and reducing the required number of secondary clarifiers.

Regional Optimization Master Plan, County of Pima, Arizona

Member Expert Peer Review Panel. This master planning effort is a 30-year treatment plant upgrade project for the Tucson metropolitan area in Arizona. A key issue in the planning effort is the fate of the two regional plants: the Ina Road Plant (37.5-mgd capacity) and the Roger Road Plant (50-mgd capacity). Issues to be addressed include reducing the impact on the dense urban environment through mitigation measures (e.g., odor control), the siting of new treatment facilities to accommodate growth (should it occur at both sites or one, or should facilities be consolidated at one site), planning for nitrogen removal, and co-location of facilities with water reclamation facilities owned by the City of Tucson to optimize and expand urban water use. Plants are required to achieve a high level of nitrogen removal and have capability for future biological phosphorus removal. Dr. Parker played a significant role in identifying appropriate treatment technologies and reviewing planning criteria.

Nitrification and Nitrogen Removal Enhancements, City of Greeley, Colorado

Process Reviewer for Capacity Rating and Enhancements. Faced with anticipated requirements requiring a higher degree of nitrification and denitrification, Dr. Parker participated in the development of field rerating studies and modeling of the plant, where unique characteristics for nitrifier growth rates and the influence of operating dissolved oxygen levels were found. This work has directly impacted the model defaults the firm and the industry uses for model platforms for the activated sludge process (e.g. BioWin). The sophisticated modeling has lead to a design project at the site.

Biological Nutrient Removal (BNR) Initiative, JEA, Jacksonville, Florida

Member Expert Panel. Dr. Parker participated in panel of experts to evaluate process kinetics and determine treatment capacities of JEA's four regional plants. The BNR initiative program has an overall goal of achieving a 50 percent reduction in nitrogen contained in its effluents discharge to the St. Johns River. Modeling and process evaluations were conducted by the firm of each panel member on one of the regional plants, ranging in capacity from 7.5 to 52.5 mgd. The $30 million program that was identified allowed JEA to most effectively meet its nitrogen reduction goal, while saving $60 million over that previously identified in a consultant report. Parker conceptualized the improvement for the Mandarin plant and went on to serve as the process reviewer for BC's design of the plant.

Advanced Waste Treatment Technology Review Committee, New York Department of Environmental Protection, New York City, New York

Chairman and Panel Member. An expert blue ribbon panel was formed in 2004 (to advise on the designs of the upgrading of five of the City's secondary treatment plants to full nitrogen removal. The panel has reviewed the designs and recommended changes to instrumentation and controls to enhance reliability as well as to add process elements that will allow the City to meet its consent degree requirements. This has included changes to aeration systems, alkalinity addition, baffle arrangements, and nuisance foam management.

Nitrogen Technical Advisory Committee, New York Department of Environmental Protection, New York City, New York

Panel Member. An expert blue ribbon panel formed in 1995 met until 2005 to advise on the research program supporting the upgrading of the City's secondary treatment plants to full nitrogen removal. The City has 14 plants processing a total average daily flow of 70 m3/s. The panel recommended process flow sheets that maximized the utilization of existing facilities that are now being pilot or full-scale tested in a $50 million dollar pilot program. Provided ongoing review of pilot program design and results. Results of these studies have saved the City hundreds of millions of dollars. Dr. Parker played a significant role in the development of process tools used for nitrogen loads in centrates, relying on the first stage of the step feed process for nitrification, thereby stabilizing nitrogen removal (this is a process developed by Parker at Appleton, WI, called the BAR process). Methods for nuisance foam management (classifying selector) that Dr. Parker had lead for Brown and Caldwell's plants were pilot tested and now are standard features of the City's new step BNR plants.

Enhanced Nutrient Removal Options, Blue Plains Advanced Water Treatment Plant, District of Columbia Water and Sewer Authority

Member Expert Peer Review Panel. This 350 mgd plant will be required to upgrade its existing nitrification/denitrification facility and reduce its average annual TN discharge from an equivalent of 7.5 mg/L to an equivalent of 4.0 mg/L. Various processes were considered including a base case of expanding the existing system to various options such as using a tertiary polishing denitrifying Moving Bed Biofilm Reactor. Dr. Parker's contributions were related to viewing the system as a whole (such as optimizing existing secondary clarifiers) so as to reduce the cost of the base case and save space. In evaluating the main alternative to the base case, Dr. Parker refined the test plan for the alternative to the base case, such as proposing a new concept termed the biofilm controlled MBBR or BCMBBR, where the two stages of treatment would be alternated to ensure a robust biofilm would always be available in this unusual polishing application. Parker reviewed the experimental work throughout its conduct and participated in commenting and editing the final technical product.

Process Evaluation, Sweden Environmental Protection Agency

Process Consultant. Dr. Parker was a consultant to the Swedish EPA on the conversion of existing plants as well as the use of new installations for nitrogen removal and enhanced nitrification for six municipalities. The largest were Gothenberg (average flow 4.0 m3/s) and Malmö (average flow 1.65 m3/s) plants that are the second and third largest plants in Sweden. He was subsequently engaged to serve as a process consultant by both wastewater agencies. He also provided technology reviews and presented technology transfer seminars to Swedish engineers.

Facility Plan, Lynchburg Regional WWTP, Virginia

Process Design Reviewer. This Chesapeake Bay discharger will be required to progressively upgrade its annual average total nitrogen and total phosphorus levels of 3 mg/l and 0.1 mg/l. After calibrating an activated sludge plant simulator to this existing 22 mgd nutrient removal plant, several upgrading alternatives were evaluated. Most attractive for detailed evaluation were several variants of the Step Feed BNR process, the Bardenpho process and the Integrated Fixed Film Activated Sludge (IFAS) process. Dr. Parker's role was QA/QC, to be sure reasonable assumptions were made and to recommend revisions to the process design when necessary.

Nitrogen Control Manual, U.S. Environmental Protection Agency

Project Manager and Senior Author. Dr. Parker was senior author of EPA's Nitrogen Control Manual (1975 edition). He also consulted to EPA on needed revisions to the manual including organization of the effort as well as a reviewer (1993 edition). The 1975 manual strongly influenced the 1993 product as well as current WEF MOPs as well as academic textbooks such as by Tchbanoglous, et al. ("Metcalf & Eddy").

Secondary Treatment Improvements and Biological Phosphorus Removal, Metropolitan Council Environmental Services, St. Paul, Minnesota

Quality Peer Review Committee Member. Dr. Parker was involved in planning and design services for secondary treatment improvements at the 250-mgd Metropolitan Wastewater Treatment Plant. Brown and Caldwell's assignments include biological phosphorus removal, wintertime nitrification (for process stability) centrifuge dewatering, levee expansion, and side stream treatment. He participated in the development of secondary clarifier modifications encompassing "fixed Towbro" suction sludge removal in rectangular sedimentation tanks that increased their capacity by 50 percent, obviating the need for a plant expansion beyond the battery limits of the plant. Process design reviews of biological phosphorus removal and nitrification elements of the plant.

Blue Lake and Seneca Wastewater Treatment Plant Facilities Planning, MCES, Minneapolis/St. Paul, Minnesota

Project Director, Liquid Stream Planning and Process Reviewer, Detailed Design. This project involved expanding the average flow capability of the Blue Lake Plant from 28 to 47 mgd and the Seneca plant from 25 to 31 mgd. Planning involved condition and capacity assessments, process proving trials for the plants innovative biological phosphorus removal system, hydraulic assessments and ancillary equipment and facility needs. Dr. Parker developed several innovative elements which were included so as to constrain needed new facilities, such as the use of separate return stream nitrification in a side stream tank fed a portion of the

return activated sludge so as to accelerate cold weather nitrification kinetics. This bioaugmentation was first developed by Dr. Parker at Appleton, Wisconsin. (BAR process). A significant expansion in wet weather treatment capacity was needed. Rather than a full biological treatment expansion of primaries, aeration tanks and secondary clarifiers, the biological contact process was used. This involves bypassing screened raw wastewater to a separate aeration tank designed for biological treatment and grit removal, and then recombination with the main plant flows prior to secondary clarification. In addition, Parker assisted in the evaluation of the stress test program of innovative anaerobic selector zone mixing using coarse bubble aeration, while preserving biological phosphorus removal in the plant. Parker subsequently served as process reviewer for the detailed design of the Blue Lake liquid process expansion.

Lower Molonglo Water Quality Control Centre, Canberra, Australia

Project Engineer. Startup and commissioning of the state-of-the-art nutrient removal plant designed to remove nitrogen and phosphorus to low levels (TN of 2.0 mg/L and TP of 0.2 mg/L). Serves the national capital of Australia (Canberra).

Process Design of Separate Stage Denitrification, Central Contra Costa Sanitary District (CCCSD) and River Oaks WWTP, Hillsborough County, Florida

Process Developer and Inventor. Dr. Parker developed (US Patent 3,953,327) an anoxic denitrification process followed by an aerated stabilization step to flocculate dispersed solids. Process development occurred at CCCSD's Advanced Treatment Test Facility, a 1-mgd demonstration facility. Employed at River Oaks plant; the plant has demonstrated attainment of effluent containing less than 2.0 mg/l of total nitrogen on a monthly average basis. Attained this goal over a 20-year period at Hillsborough County, FL. In a recent WEF/WERF survey, the plant was found to be one of the two plants nationwide to produce the lowest level of effluent TN.

Biofilm Controlled Nitrifying Trickling Filter (BCNTF), Various Clients

Inventor/Process Engineer/Reviewer. The BCNTF is a nitrifying trickling filter placed downstream from conventional secondary treatment and has demonstrated high nitrification rates and smaller structures than previously used. Pilot tested at Central Valley, Utah and Malmö, Sweden. Dr. Parker was the technical reviewer or process designer for applications at Central Valley, Utah; Fulton County, Georgia; Malmö, Sweden; Boulder, Colorado and Littleton/Englewood, Colorado. Dr. Parker was process consultant for full-scale rerating studies at latter two client sites.

Development of the Classifying Selector

Co-inventor and Developer. Biological nutrient removal plants often suffer from nuisance foam conditions, causing effluent problems as well as anaerobic foaming. A selector developed in South Africa saw no full-scale trials there, but a beta version was first tested by City of Atlanta staff at the Utoy Creek plant. Nuisance organisms are removed as soon as they are formed through use of continuous flotation in aerated channels. The concept was refined and applied first at the Sacramento Regional WWTP by BC and other plants such as in modified form by BC at Atlanta's Utoy Creek plant, along with MCES's Metro and Blue Lake plants, a Cobb County's South, El Paso's Haskell St. plant, Dublin San Ramon Services plant and in many other of BC's activated sludge designs. Based on published research by BC, a number other design firms have now implemented them as well.

Development of the Biological Contact Process

Inventor and Process Reviewer. The biological contact process borrows inventory from a mainstream activated sludge process, such as a BNR plant, and in a short residence aerated tanks bioflocculates particles and oxidizes soluble organics before passing the mixed liquor onto high rate secondary clarification; settled solids are returned to the mainstream process. This allows plants to meet wet weather treatment needs without bypass and comply with secondary treatment regulations. A recent development, its first application is at OWASA's Mason Farm plant in North Carolina (a BNR plant).

Development of Three Bioaugmentation Processes for Accelerated Nitrification (BAR, BASIN, TF/PAS)

Inventor/Developer for BAR Process. The BAR processes directs ammonia laden reject water from dewatering of digested sludges to a reaeration tank whereby complete nitrification is achieved; nitrifiers are the transferred to the contact tank, thereby accelerating the mainstream nitrification process. The process was

first used by Brown and Caldwell in the early nineties at Appleton, WI and is now incorporated in a Brown and Caldwell design under construction at the MCES Blue Lake plant, near St. Paul, MN. Now adopted widely in the wastewater industry, it has been incorporate into a number of European plants, as well as designs for New York City, Metro Denver and others in the US.

Co-Inventor/Developer/Process Consultant for TF/PAS Process. The Trickling Filter/Pushed Activated Sludge (TF/PAS) process was developed out of observations made during the pilot study and full-scale operation of the City of Garland's TF/SC plant. Design for partial nitrification in the TF allowed for completion of nitrification in the downstream solids contact tank, even at low solids residence times. After its discovery at Garland, further pilot testing at the City of Atlanta's research center, it was subsequently designed by BC for the Central Valley Water Reclamation Facility in Utah, and the City of Melrose in Minnesota.

Inventor/Co-Developer for BASIN Process. The BASIN process uses a moving bed biofilm reactor directly coupled to an activated sludge step. The differentiation of this patented process is that intensive shearing at low night time flows allow wasting of the sloughed biomass away from the following activated sludge step (thereby resulting in nitrifier enrichment there) and to the primary clarifier. Tested at bench-scale, it has not yet seen a full-scale application.

Nitrogen Control Plants Process Engineering, Various Clients

Process Design Consultant or Process Engineer. Nitrogen control plants including: Gwinnett County, Georgia; Santa Fe, New Mexico; Boulder, Colorado Springs and Littleton-Englewood, Colorado; El Paso, Texas, Sunnyvale, California; Hillsborough County, Florida; Corvallis, Oregon; Central Valley (South Salt Lake), Utah and Appleton, Wisconsin.

IFAS Model Development, Brown and Caldwell

Project Manager. The Integrated Fixed Film Activated Sludge (IFAS) process has been implemented with empirical models and models of biofilms with activated sludge kinetics for enhanced nitrification in small activated sludge reactors. To improve designs, Dr. Parker supervised the development of a new IFAS model based on the best fixed film research available and then calibrated it against existing plant data. The model allows identification of appropriate applications in alternative analyses and optimization of the IFAS process for design.

Littleton/Englewood Wastewater Treatment Planning and Design, Colorado

Process Engineer and Process Design Reviewer. Dr. Parker has been involved with this client since the beginning of Brown and Caldwell's remodeling and expansion of the plant, beginning in the mid-eighties and continuing to date. A high rate activated sludge plant and parallel rock tricking filter plant were converted to a Trickling Filter/Solids Contact process followed by nitrifying trickling filters (NTFs). The NTFs also provide treatment of foul gases and provide excellent odor removal. Later expansions involved changes to digestion and dewatering and included the addition of tertiary denitrification filters. Detailed process models were developed, calibrated and then recalibrated as plant units came on line. Today this is a 50 mgd plant providing full nitrogen removal, while in 1985 it was rated at 27 mgd and provided only secondary treatment.

Biofilm Controlled Nitrifying Trickling Filter (BCNTF), Various Clients

Developer. The BCNTF is a nitrifying trickling filter placed downstream from conventional secondary treatment and has demonstrated high nitrification rates and smaller structures than previously used. Pilot tested at Central Valley, Utah and Malmö, Sweden. Dr. Parker was the technical reviewer or process designer for applications at Central Valley, Utah; Fulton County, Georgia; Boulder, Colorado and Littleton/Englewood, Colorado. Dr. Parker was process consultant for full-scale rerating studies at latter two sites.

BCNTF pilot study, City of Malmö, Sweden

Process Engineer/Consultant. Dr. Parker served as a process consultant for the two-year pilot that used two 10-ft-diameter test filters to establish the conditions which would maximize tertiary nitrification in the City's existing trickling filters. The study minimized the cost of conversion of the plant to advanced wastewater treatment for nutrient removal.

Johns Creek Environmental Campus, Fulton County, Georgia

Process Design Reviewer. This facility is a 15 mgd Membrane Bioreactor (MBR) water reclamation facility. Using a design-build approach, this below ground facility includes an influent pump station, bar screens, vortex type grit removal, double entry type fine screens, primary clarification, aeration basins incorporating biological nutrient removal (limit is 0.13 TP), membrane tanks, UV disinfection and post aeration. Solids processing includes aerobic digestion and centrifugal dewatering. Parker's role was QA/QC, to be sure reasonable assumptions were made and to recommend revisions to the process design when necessary.

Blue Ribbon Panel, City of Atlanta, Georgia

Panel Chairman. A Blue Ribbon Panel was formed to advise on effluent compliance and plant operations (performance and cost) for the City's three largest wastewater treatment plants. The plants must meet a pooled effluent total phosphorus limit of 0.7 mg/l with their existing facilities prior to a major upgrading program that is currently underway. The plants lacked the effluent filtration units that ultimately will allow them to reliably meet this requirement. The BRP was initiated after an upset in February 1997. Implementation of operation recommendations and independent City actions has resulted in an unblemished compliance history for phosphorus for 44 months. Cost reduction recommendations have also been made.

Atlanta Region Sub-Area Future Wastewater Treatment Feasibility Study, Atlanta Regional Commission, Georgia

Technical Review Board Member. Brown and Caldwell prepared this feasibility study for the four-county area surrounding and including the City of Atlanta. This study planned for regional treatment needs to the year 2040, when average flows are expected to reach 540-mgd. Regional consolidation was considered because of the need to upgrade all the area's wastewater treatment plants to advance degrees of phosphorus removal. Considered varying degrees of subregional and regional consolidation as well as the need to consider future water reclamation needs in the as yet undeveloped areas due to potential future water supply shortages. Served in the same role for the City of Atlanta's comprehensive control plan which developed the concept of linking the city's three plants by pipelines and tunnels to optimize CSO control, phosphorus removal, and shift loads.

Lime and Iron and Lime Use for CEPT Design Manual, U.S. Environmental Protection Agency

Project Manager. Senior author of the process design manual Lime Use in Wastewater Treatment: Design and Cost Data. The manual covers the fundamentals of lime, handling of lime, liquid processing, lime sludge thickening and dewatering, lime reclamation, air quality, ash disposal and cost estimating.

Biological Phosphorus Removal Plants Process Engineering, Various Clients

Process Design Consultant or Technical Reviewer. Process design for biological phosphorus removal at various plants, including the City of Atlanta's Utoy Creek plant; Fulton County, Georgia and the Unified Sewerage Authority, Durham, Oregon.

Biological Aerated Filter (BAF) pilot study, City of San Diego, California

Technical Advisor, Q/QC. Served as a process consultant for the yearlong pilot that trialed two BAF vendor's designs for the 250 mgd Point Loma plant. Reviewed and modified the experimental design, so that data that would support the future design of BAFs on this constrained site. Assisted in data interpretation and drawing conclusions from this important study. While performance was similar for the Biostyr and Biofor units, sludge production was significantly different, a difference that was only determined after procedures were developed to allow a full mass balance to be done on the BAFs. Other innovative testing including oxygen transfer testing and determination of impact of nitrifier seeding on exertion of nitrogenous oxygen demand with the five-day BOD test.

Haskell R. Street Wastewater Treatment Plant, El Paso Utilities, Texas

Project Reviewer. This 29 mgd plant was converted to from high purity oxygen activated sludge to a nitrifying plant with two types of selectors for bulking control (anaerobic and classifying). Parker reviewed the process design and suggested appropriate changes as well as assisted in process startup. The plant has operated without foam and very low and stable SVIs.

Clean Water Master Plan, Scope B Wastewater Treatment, City and County of San Francisco Public Utilities Commission (SFPUC), San Francisco, California

Treatment Technology Lead. Dr. Parker is the treatment technology lead for this significant planning effort. He provides technical direction to the engineering staff. The project involves a 30-year time horizon for the planning for San Francisco's wastewater treatment. The City's 22-mgd Oceanside Wastewater Treatment Plant and the 80-mgd Southeast Wastewater Treatment Plant must be reconfigured and rehabilitated for anticipated future requirements. The Southeast plant is sited in one of the more blighted areas of the City, and there have been historic environmental justice issues with the site. Consideration is being given to either completely screening it like the Oceanside plant with significant changes to its odor control system, or replacing it at a new site either on the ocean side of the City or on the bayside. Consideration is being given to decentralizing the plant into as many as three bayside locations. Because of space constraints at existing and new sites, compact treatment technologies are being favored, including deep aeration tank processes, biologically augmented processes, and very compact technologies (biological aerated filters and membrane bioreactors). Bayside locations are being planned for advanced wastewater treatment because of the higher receiving water quality anticipated in the future and including layouts for both nitrification and effluent filtration facilities. Both existing and new sites are being considered for centralized solids processing facilities, again with consideration of the aesthetic development of the sites, all which exist in a dense urban environment. Small, decentralized wastewater plants are being considered to make up part of the water deficit projected in the City's Water Master Plan. The work is being done in collaboration with SFPUC, which is taking on some of the site considerations using the design criteria developed by Brown and Caldwell. Sustainability is a hallmark of the treatment plant and overall planning effort. The work is being integrated with the rest of the master planning efforts being carried on in parallel with other firms, including work on upgrading the combined sewer system and planning for low impact development as the City gradually redevelops over time.

Review of Strategic Sewage Disposal Scheme Stage II Options, Hong Kong Government Environmental Protection Department, China

Peer Reviewer and Process Specialist. Reviewed all the unit process capability descriptions and plant layouts as well as the alternative schemes and their impact on water quality. The review was prepared for the Hong Kong Environmental Protection Department by Pypun Engineering Consultants. Provided key input on the capabilities of chemical primary treatment/secondary treatment combinations and UV disinfection to the study team as well as to the Hong Kong Government appointed Review Panel.

Belmont TF/SC Design for Wet Weather Treatment, City of Indianapolis, Indiana

Process Engineer. This proposed 60-mgd (ADWF) facility places a TF/SC process ahead of an existing nitrifying high oxygen activated sludge (HPOAS) process, so as to double the facilities secondary treatment capability for treating combined wastewater flows from a tunnel/storage system. During wet weather, the TF/SC process is decoupled from the downstream HPOAS system. Dr. Parker determined the process size using BC developed process design programs; this included trickling filter sizing, media selection, aeration tank and flocculator clarifier sizing.

TF/SC Design for Full Secondary at Plant 2, Orange County Sanitation District, California

Process Engineer. This new 60 mgd (ADWF) facility follows primary treatment operated with chemical addition to reduce the loading and sludge production from the secondary treatment process. Dr. Parker determined the process size using BC developed process design programs; this included trickling filter sizing, media selection, aeration tank and flocculator clarifier sizing. In order to protect the parallel secondary process from washout, the TF/SC process had to sustain peak flows up to 170 mgd. He used CFD modeling to establish clarifier peak overflow rates sustain able during infrequent but high flow events.

Preliminary Evaluation of Fixed Film Reactor Media Condition, City of Modesto, California

Project Engineer. Dr. Parker performed the assessment and evaluation of the fixed film reactor (FFR) media. The inspection consisted of surface inspection of the media, without removing or damaging any of the media. Based on the assessment, it was concluded that the worst damage was sustained on the FFR 2 media. Dr. Parker recommended a survey of FFR 1 be conducted to determine if shifting of the structure had occurred. An additional recommendation was for a detailed investigation to be conducted to investigate the possibility of damage to the underlying layers.

Water Pollution Control Facility Plan, City of Hayward, California

Process Engineer. Dr. Parker served as process engineer for evaluation of the fixed film reactor at the Water Pollution Control Facility (WPCF). He designed sampling program for establishing an overall plant mass balance. During the course of the investigation, internal plant recycles and process inefficiencies were identified that have allowed the plant staff to make incremental improvements to the plant's effluent quality. He prepared process designs for the four alternatives evaluated during the Master Plan (modifications to the existing process, upgrading with chemical addition, the TF/SC process and activated sludge). Dr. Parker input to the development of cost evaluation, attended workshops of cost evaluation and attended workshops with City of Hayward public works and WPCF staff.

Assistance in Negotiations and Review for Advanced Water Treatment Facility, City of Hayward, California

Consultant to Public Works Director and Assistant Public Works Director (and Project Manager). The Calpine/Bechtel Joint Development Company proposes to construct a 600 MW plant adjacent to the City of Hayward's WPCF. There is agreement that cooling water will be served from an Advanced Water Treatment Facility (AWTF) that will produce reclaimed water from the City of Hayward's WPCF. The AWTF will be designed and constructed by Calpine/Bechtel and turned over to the City for ownership and operation. Brown and Caldwell was engaged to provide Dr. Parker to serve as the principal engineering consultant to City staff to advise during contract negotiations. In addition, Dr. Parker has managed the firm's review of Calpine's proposals for the AWTF preliminary planning and detailed designs. He has helped the City obtain superior technologies for water treatment, and for metals removal from AWTF reject water streams. In addition, the interrelationships between the AWTF and WPCF have been optimized. As an example of process improvements, promising metals removal chemicals have been identified to replace the favored high lime treatment (with its onerous sludge production). With respect to reactor units, a problem in dealing with scaling was identified with a favored reactor clarifier unit, causing Calpine/Bechtel to select a lower maintenance technology. A deficiency in building arrangements for maintenance activities, offices and locker rooms was identified and improvements and costs suggested to the City for negotiation with Calpine/Bechtel. A facility layout was proposed and then adopted by the City that moved some of the process units to the WPCF site, allowing greater expandability to the water treatment facilities so that other future users could be served from an integrated, single facility.

Pond Improvements, Napa County Sanitation District, California

Process Consultant. Dr. Parker consulted on reconfiguring oxidation ponds to prevent odor development. He conceived modifications to clarifiers to operate as dissolved air flotation units (DAFs) for algae removal.

Algae Separation and Concentration, LiveFuels, Menlo Park, California

Process Consultant. Dr. Parker helped develop algae separation and concentration technologies for this start-up biomass to energy company. Details are confidential.

Algae Separation and Concentration, Sapphire Energy, San Diego, California

Process Consultant. Development of algae separation and concentration technologies for this start-up biomass to energy company. Details are confidential.

Algae Removal, City of Modesto, California

Process Consultant. Fast track project to install 6 mgd of algae removal capacity to allow pond discharge during a formerly "no discharge" low flow period for the San Joaquin River. Consulted on identification of new high rate DAF technology with a novel air dissolution system.

Stage 1 Liquid Waste Management Plan, Greater Vancouver Regional District, British Columbia

Senior Expert Consultant. This planning study for the urbanized area that includes Vancouver covered a 50-year planning horizon for a year 2036 population of 2.7 million. Assessment of the existing water quality in the region's water bodies established the initial priorities for planned improvements. Dr. Parker's role was to provide management level input to the study and provide technical review of all study efforts including water quality assessment, urban and rural run-off, combined sewer overflows, wastewater discharge impact, treatment needs, sludge processing and disposal, and industrial source control.

Annacis Island and Lulu Island Secondary Treatment Facility Predesign and Design, Greater Vancouver Regional District (GVRD), British Columbia

Project Director. Starting in the late 1980s, Denny served as the senior expert consultant to GVRD for its Stage 1 Liquid Waste Management Plan. This planning study for the urbanized area that includes Vancouver and surrounding cities covered a 50-year planning horizon for a year 2036 population of 2.7 million. Assessment of the existing water quality in the region's water bodies established the initial priorities for planned improvements. Denny provided management-level input to the study and provided technical review of all study efforts, including water quality assessment, urban and rural run-off, combined sewer overflows, wastewater discharge impact, treatment needs, sludge processing and disposal, and industrial source control.

The Annacis Island (MMF of 204-mgd) and Lulu Island (MMF of 21-mgd) wastewater treatment plants feature the use of the Trickling Filter/Solids Contact process for secondary treatment and provide anaerobic digestion and sludge dewatering. Both plants have extensive covering and odor control features and the larger plant will provide thermophilic digestion in a series mode for production of Class A sludge for unrestricted beneficial reuse. Master planning elements of the predesign effort included detailed evaluations of treatment alternatives and plant locations, a sludge reuse master plan, and an assessment of infiltration/inflow in the separated portions of the system.

Secondary Treatment for Regional Plant, Sacramento Regional County Sanitation District, California

Project Engineer for Planning/Project manager for Pilot Study/Process Reviewer for Design/Process Consultant on Operations. In the 70s, served as process engineer that compared secondary treatment alternatives for the regional plant—conventional activated sludge was compared to oxygen-activated sludge and the latter was selected because of increased process stability for treatment of seasonal canning wastewaters. Dr. Parker laid out site for future nitrogen removal using a three-sludge system to reserve space on the site. Subsequently, Dr. Parker was project manager on the pilot plant study that defined oxidation tanks and secondary clarifier design criteria for the Sacramento Regional Wastewater Treatment Plant. He provided technical review on the final process design and for the subsequent expansion. Dr. Parker was the process consultant on operating problems relating to Nocardia foam generation and oxygen transfer in the regional plant. He also was the process designer for a classifying selector installation on the RAS channels and with consultation on its effectiveness after startup.

Roger Road Treatment Investigation: Proposed Changes to Remedy High Effluent Solids, Pima County, Arizona

Process Engineer. Denny investigated alternatives to upgrade the plant, including process changes in the aeration basins, as well as potential conversion to a TF/SC process.

Biological Treatment Pilot Study, City of Windsor, Ontario

Expert Process Control Consultant. Pilot study of biological treatment following an existing chemically enhanced primary treatment process. The coagulants used are low dose iron and anionic polymer and are applied for phosphorus removal. Processes tested for BOD polishing and nitrification are Biological Aerated Filters (BAFs) and the Trickling Filter/Solids Contact Process followed by UV irradiation. Completely redesigned the TF/SC pilot to enhance flocculation and provided operations guidance so that process was moved from the failing category to where its effluent equaled that of the BAF process. Directed predesign of full-scale trickling filter facilities.

Pilot Studies of Iron Coprecipitation of Heavy Metals, Electric Power Research Institute, Palo Alto, California

Principal-in-Charge. Studies were conducted at the Carolina Power and Light Company, Roxboro, North Carolina, and the Pennsylvania Power and Light Company, Washingtonville, Pennsylvania, USA. Designed, constructed, and operated an iron coprecipitation pilot plant (55 m3 capacity) to metals from power plant effluents. This test program evaluated the effects of iron dose (ferric chloride), mixing, flocculation, and clarifier overflow rate on arsenic and selenium removal. The study also evaluated sludge production (as influenced by chemical dose and raw water quality), sludge thickening rates (via column testing), and sludge dewatering performance (via bench-scale filter press operations). Both pilot studies concluded with a cost analysis (capital, operating and maintenance, and life-cycle costs) of the treatment process.

Addition of Chemically Enhanced Primary Treatment (CEPT) Facilities, Orange County Sanitation District (OCSD), California

Process Consultant. Denny evaluated high rate alternatives to CEPT, including ballasted sedimentation and plate separators as well as enhancement to CEPT including improved chemical addition, flocculation and sedimentation tank features. Prepared experimental design for field program and 2-D hydrodynamic modeling and evaluated the cost-effectiveness of alternative improvements. Recommended improved coagulant dosage control and point of chemical addition and provided process design input into detailed design of 156 mgd of new and updated facilities.

Combined Sewer Overflow Control Plan Five-Year Update, King County Department of Natural Resources, Washington

Board Member/Technical Review. Work tasks include consideration of Seattle metropolitan system interactions using Metro's models, development of decision-making criteria, and identification and evaluation of alternatives. Alternatives considered include separation, storage, capacity improvements and treatment. Relative impacts on water quality using risk assessment techniques were used in ranking the alternatives.

San Diego Clean Water Program Framework Plan, San Diego Metropolitan Wastewater Department, California

Technical Advisory Board Member. This comprehensive framework plan (master plan) provides for sewage collection, treatment, effluent and sludge disposal as well as water reclamation for the service area until the year 2050. Projected service area population at that time is 2.8 million.

Wastewater Facilities Planning Study, City of Santa Cruz, California

Project Manager. A 1.7 million dollar master planning effort for the metropolitan area centered on Santa Cruz, California. This planning effort encompassed oceanographic studies to support outfall design, extensive reclamation studies done jointly for Santa Cruz and the City of Watsonville, analysis of alternatives to prevent seawater intrusion into the aquifer underlying the Pajaro Valley, evaluation of alternative treatment plant and sludge disposal sites, and evaluation and wastewater treatment and solids process and disposal alternatives including codisposal with solid waste in an energy recovery facility.

Plan of Study Development of Toxicant Pretreatment Planning Study (TPPS), King County Department of Natural Resources, Washington

Project Manager. This multiyear, multimillion-dollar investigation studied the source of toxic pollutants (organics and metals) in the service area, their transformation and removal through treatment processes, and their ultimate fate in sludges, to the air, or to the environment. The TPPS also quantified industrial and commercial and residential sources, examined pretreatment and household source control effectiveness, and proposed changes to Metro's pretreatment system. Served as technical reviewer for collection and treatment system evaluations.

Water Reclamation Studies, Various Clients, California

Principal-in-Charge. Water reclamation studies for the City of San Jose's San Jose-Milpitas-Santa Clara water reclamation project and the Napa-American Canyon Wastewater Reuse program.

Wet Weather Facilities Plan, East Bay Municipal Utility District, California

Project Manager. Planned new interceptors and storage facilities to capture overflows from the District's separated collection system during wet weather events.

Sludge Handling and Treatment Investigations, East Bay Municipal Utility District, California

Principal-in-Charge. Study included a compost pilot study, sludge stabilization optimization, in plant treatment optimization and an economic and technical evaluation of sludge processing, recycling and disposal alternatives.

Clarifier Evaluation, East Bay Municipal Utility District, California

Principal-in-Charge. Dye studies of the District's rim feed/rim flow clarifiers and member of a blue ribbon committee that recommended modifications to these units to combat destabilizing density currents causing direct short-circuiting from influent to effluent.

Flocculation Process Research, Clemson University, South Carolina

Adjunct Professor. Research on activated sludge flocculation and breakup that has led to design practice recommendations for reducing the levels of suspended solids in activated sludge effluents.

Secondary Clarifier Improvements, Various Clients

Process Consultant. Modifications to secondary clarifiers to improve suspended solids removal at Lincoln, Nebraska; Colorado Springs, Colorado; San Mateo, California; Boise Cascade's International Falls plant, Minnesota; International Paper's plant, Vermont; Albany, Georgia and Pierre, South Dakota.

Research Priorities for Debottlenecking, Optimizing and Rerating Wastewater Treatment Plants Water Environment Research Foundation (WERF), Report for Project 99-WWF-1

Project Subcommittee Chair. Organized and led the agenda-setting workshop that originated WERF's optimization program that has lead to projects on development of protocols for rerating primary clarifiers, activated sludge and secondary clarifiers (all subsequently developed by BC for WERF).

Determine the Effect of Individual Wastewater Characteristics and Variances on Primary Clarifier Performance, Draft Final Report for Project 00-CTS-2

QA/QC Reviewer. Reviewed the original draft and comments of external reviewers and recommended changes.

Methods for Wastewater Characterization in Activated Sludge Modeling, WERF

Reviewer and Advisor. Served as QA/QC reviewer for the preparation of the protocol.

Clarifier Testing Protocol, ASCE's Clarifier Research Technical Committee (CRTC) and WERF's Final Protocol (Project 00-CTS-1)

Steering Committee Member. Worked on testing protocol development and reviewed site testing reports from LASCD, Denver Metro, and New York City. Served as QA/QC reviewer for the revision of the protocol for the Water Environment Research Foundation. Testing procedure is now accepted as the industry standard.

Secondary Settling Tanks Report, International Association of Water Quality

Member of the Author Panel. Scientific and technical report on secondary settling tanks.

Trickling Filter/Solids Contact (TF/SC) Process, Various Clients

Project Director. Co-inventor of the Trickling Filter/Solids Contact (TF/SC) process first tested full-scale at Corvallis, Oregon. Directed full-scale studies funded by EPA at Corvallis, Oregon; Tolleson, Arizona; Oconto Falls, Wisconsin; Medford, Oregon and Morro Bay (California). Process consultant for TF/SC pilot studies for Omaha, Nebraska; Everett, Washington; Stockton, California; Garland, Texas; Chino Basin Municipal Water District, California; Windsor, Canada and Atlanta, Georgia. Technical reviewer or process consultant for TF/SC plant rerating studies at Tolleson, Arizona; Central Valley, Utah; Boulder, Colorado; Littleton/Englewood, Colorado and Monterey, California. Process designer for the Greater Vancouver Regional District's TF/SC plants at Annacis Island and Lulu Island.

Development of the Flocculator-Clarifier

Process Engineer and Inventor. First full-scale test of a clarifier with a flocculator centerwell in full-scale practice was in 1979 at Corvallis, Oregon and Santa Rosa, California. Flocculator-clarifiers have been able to obtain an effluent TSS of 10 mg/L of effluent total P without filtration. Subsequently employed at multiple sites, including: Santa Rosa, California; Central Valley, Utah; Sacramento, California; Atlanta, Georgia; Gwinnett County, Georgia; Cobb County, Georgia; Vancouver, Canada; Santa Cruz, California, Appleton, Wisconsin and other clients.

Italian Municipal TF/SC Plants and Industrial Waste Applications

Principal-in-Charge and Project Manager. Process designs and support services for Smogless, s.p.a., an Italian turnkey constructor.

Georges River and Botany Bay Water Quality Modeling, Sydney Water, Sewer and Drainage Board, Australia

Project Manager. This investigation studied the effect of upstream organic and nutrient sources on the river and estuary and predicted the biostimulation that later occurred with development. Advanced wastewater treatment for nutrient removal was recommended and later was implemented by the Board.

Floc Breakup, City of Gothenberg, Sweden

Project Director. Evaluation of the effects of mixed liquor pumping. The City proposed a plant expansion with double-decked clarifiers and found that sludge pumping seemed to breakup the floc, resulting in higher effluent suspended solids and effluent phosphorus levels that would exceed permit levels. A field study of Archimedes screw pumping showed that indeed floc breakup was occurring, but that it could be mitigated by a flocculation step after sludge pumping.

Chemically Enhanced Primary Treatment Pilot Study, Central Contra Costa Sanitary District, Concord, California

Project Manager. Prototype scale pilot study of chemical primary treatment followed by nitrogen removal for testing of chemically enhanced primary treatment used a full-scale tank having a capacity of 0.11 m3/s. In two years of testing, major test variables were pH (10.2 to 11.5), supplemental coagulant dose (ferric chloride from 0 to 24 mg/l) and various overflow rates. This facility supported Brown and Caldwell's design for both the 1.31 m3/s (ADWF) CCCSD plant as well as the 1.27 m3/s (ADWF) Lower Molonglo Water Quality Control Centre (LMWQCC) for Canberra, Australia.

Refinery Wastewater Plant Upgrades, Various Clients

Process Reviewer or Principal-in-Charge. Upgrade studies and predesigns for refineries including Exxon's Baytown Refinery (Texas), Shell's Martinez refinery (California), and Union Oil's San Francisco refinery (California).

Pulp and Paper Wastewater Treatment Plant Upgrades, Various Clients

Principal-in-Charge. Studies or predesigns at seven pulp and paper plants for clients including Boise Cascade, James River, and International Paper.

Site Assessments, Various Clients

Principal-in-Charge. Contaminated site assessment for numerous clients including Westinghouse, Southern Pacific, and Union Chemical Company.

Metals Removal Process, Electric Power Research Institute

Principal-in-Charge. Selenium and arsenic removal from coal fired power plants using iron coprecipitation technology. Technology demonstrated capability to remove metals down to microgram per liter levels.

Memberships

American Society of Civil Engineers
American Water Works Association
International Water Association
National Academy of Engineering
Water Environment Federation
Water Environment Research Foundation
WERF Board, 1988-1989
WERF Research Council, Chair, 1989-1993
WERF Research Council, Member, 1994-1998

Publications/Presentations

A separate list of publications is available.

Honors/Awards

ASCE's Samuel Arnold Greeley Award, 1977

WEF's George Bradley Gascoigne Medal, 1983

ASCE's Simon W. Freese Award, 1987

WEF's Harrison Prescott Eddy Medal, 1995

AEEP's Outstanding Publication Award, 1995

WEF's Thomas R. Camp Medal for Basic Research Contributions to Wastewater Applications, 2003

Elected to the National Academy of Engineering, 2004

Publications/Presentations

1. "Water Quality Management and the Time Profile of Benefits and Costs," Water Resources Research, Vol. 4, No. 2, pp. 233-246, April 1968.
2. "Unit Process Performance Modeling and Economics for Cannery Waste Treatment," with John R. Monser and Robert G. Spicher, proceedings of the 23rd Purdue Industrial Waste Conference, Purdue University, Lafayette, Indiana, pp. 710-739, May 7-9, 1968.
3. "Effect of Turbulence on Activated Sludge Effluent Clarity," presented at the Twelfth Annual Northern Regional Conference of the California Water Pollution Control Association (now the California Water Environment Association), Stockton, California, October 3, 1970.
4. "Physical Conditioning of Activated Sludge Floc," with Warren J. Kaufman and David Jenkins, Journal Water Pollution Control Federation (now the Water Environment Federation), Vol. 43, No. 9, pp. 1817-1833, September 1971.
5. "Floc Breakup in Turbulent Flocculation Processes," with Warren J. Kaufman and David Jenkins, Journal of the Sanitary Engineering Division, Proceedings of ASCE, Vol. 98, No. SAI, pp. 79-99, February 1972.
6. "Tidal Exchange at Golden Gate," with Dan P. Norris and Austin W. Nelson, Journal of the Sanitary Engineering Division, Proceedings of ASCE, Vol. 98, No. SA2, pp. 305-323, April 1972.
7. "Full Scale Test Plant at Contra Costa Turns Out Valuable Data on Advanced Treatment," with David G. Niles, Bulletin of the California Water Pollution Control Association (now the California Water Environment Association), Vol. 9, No.1, pp. 25-27, July 1972.
8. "Improving Pond Effluent by Algae Removal," with James B. Tyler and Thomas J. Dosh, Water and Wastes Engineering, Vol. 10, No. 1, January 1973.
9. "Marine Waste Disposal, A Comprehensive Environmental Approach to Planning," with Dan P. Norris, Lawrence E. Birke, Jr. and Robert T. Cockburn, Journal Water Pollution Control Federation (now the Water Environment Federation), Vol. 45, No. 1, pp. 52-70, January 1973.
10. "Full-Scale Testing of a Water Reclamation System," with D. H. Caldwell, G. A. Horstkotte and D.G. Niles, Journal Water Pollution Control Federation (now the Water Environment Federation), Vol. 46, No. 1, pp. 181-197, January 1974.
11. "Nitrification and Denitrification Facilities," prepared for the EPA Technology Transfer Design Seminar for Wastewater Treatment Facilities, Boston, Massachusetts, September 10, 1974.
12. "Processing of Combined Physical-Chemical-Biological Sludge," with David G. Niles and Fred J. Zadick, Journal Water Pollution Control Federation (now the Water Environment Federation), Vol. 46, No. 10, pp. 2281-2300, October 1974.
13. "Carbon Oxidation-Nitrification in Synthetic Media Trickling Filters," with Richard J. Stenquist and Thomas J. Dosh, Journal Water Pollution Control Federation (now the Water Environment Federation), Vol. 46, No. 10, pp. 2327-2339, October 1974.
14. "Upgrading Lagoon Effluent for Best Practicable Treatment," with R. W. Stone and J. A. Cotteral, Journal Water Pollution Control Federation (now the Water Environment Federation), Vol. 47, No. 8, pp. 2019-2042, August 1975.
15. "Lime Recovery and Reuse in Primary Treatment," with Geoffrey A. Carthew and Gerry A. Horstkotte, Journal of the Environmental Engineering Division, Proceedings of ASCE, Vol. 101, No. EE6, pp. 985-1004, December 1975.
16. "Performance of Alternative Algae Removal Systems," Water Resources Symposium Number Nine: Ponds as a Wastewater Treatment Alternative, Center for Research in Water Resources, College of Engineering, The University of Texas at Austin, pp. 401-416, 1976.
17. "Design of an Integrated Approach to Nutrient Removal," with David L. Eisenhauer and Ronald B. Sieger, Journal of the Environmental Engineering Division, Proceedings of ASCE, Vol. 102, No. EE1, pp. 37-54, February 1976.
18. "A Discussion of 'Air or Oxygen Activated Sludge,'" presented at the 48th Annual Conference of the California Water (now the California Water Environment Association) Control Association, South Lake Tahoe, California, April 14-16, 1976.
19. "Oxygen and Air Activated Sludge: Another View," with M. S. Merrill, Journal Water Pollution Control Federation (now the Water Environment Federation), Volume 48, No. 11, November 1976.
20. "Development and Implementation of Biological Denitrification for Two Large Plants," with Richard C. Aberley and David H. Caldwell, Prog. Wat. Tech., Vol. 8, Nos. 4/5, pp. 673-686, 1977.

21. "Long-Term Performance of a Coupled Trickling Filter-Activated Sludge Plant," Journal Water Pollution Control Federation (now the Water Environment Federation), Vol. 49, November 1977.
22. "A Unified Theory of Filamentous Activated Sludge Bulking," with Mesut Sezgin and David Jenkins, Journal of Water Pollution Control Federation (now the Water Environment Federation), Vol. 50, pp. 362-381, February 1978.
23. "Discussion of 'Nitrification Design Approach for High Strength Ammonia Wastewaters,'" with P.M. Sutton, Journal Water Pollution Control Federation (now the Water Environment Federation), Vol. 50, pp. 2050-2053, August 1978.
24. "Secondary Treatment Alternatives: Suspended Growth," Journal of the Environmental Engineering Division, Proceedings of ASCE, Vol. 105, No. EE2, pp. 283-296, April 1979.
25. "Evaluation of Ozone Treatment in Cooling Towers," with Douglas T. Merrill and Joseph A. Drago, proceedings of the 35th Annual Purdue Industrial Waste Conference, Purdue University, Lafayette, Indiana, pp. 307-315, May 13-15, 1980.
26. "Efficiencies of Advanced Waste Treatment Obtained with Upgraded Trickling Filters," with Dan P. Norris and Marvin L. Daniels, Civil Engineering, ASCE, Vol. 50, No. 9, pp. 78-81, September 1980.
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